UNIT 4 - ENVIRONMENT
SECTION 1 - OZONE ALERT

Vocabulary

air pollution	**exosphere**	**ozone layer**	**topography**
asthma	**ground-level ozone**	**reactive emissions**	**troposphere**
atmosphere	**mesosphere**	**simple hydrocarbon**	**ultraviolet radiation**
diatomic	**nitrogen**	**stratosphere**	**volatile**
evaporative emissions	**nitrogen oxides**	**stratospheric ozone**	**volatile organic compounds**
exhaust emissions	**ozone**	**thermosphere**	

Ozone is a highly reactive molecule consisting of three oxygen atoms. Ozone occurs throughout the troposphere, which is the lowest layer of the **atmosphere.** Ozone is only a problem at ground level (Figure 4-1-3).

Small amounts of ground-level ozone have always been present and are naturally produced from soil emissions, thunderstorms, and forest fires. Human activities, however create enough additional ground-level ozone to be a hazard to health and to damage plants and buildings. Ozone causes the most serious health problems for young children, some elderly people, and people with lung conditions such as **asthma**.

Good Ozone/Bad Ozone

People are sometimes confused when they hear that on the one hand the destruction of the **ozone layer** is dangerous to the planet, but on the other hand ozone itself is hazardous. The difference is not in the ozone, but in where the ozone is. This section focuses on "**ground-level" ozone**, which is hazardous to living beings. But you need to know about the "good" ozone in the atmosphere, too.

Stratospheric ozone is created by the sun's radiation. Stratospheric ozone makes up a layer in the atmosphere that absorbs most of the high-energy

What is the atmosphere made of?

Exosphere
Helium, hydrogen, & oxygen

Lower Layers

Gas	*%*
Nitrogen	*78*
Oxygen	*21*
Trace gases	
Argon, Carbon dioxide, Neon, Helium, Krypton, Hydrogen, Xenon, Ozone	*...1*

Plus: *Water vapor, microscopic dust particles, plant spores, and pollen.*

Source: *National Oceanic and Atmospheric Administration*

Figure 4-1-1 Components of the atmosphere

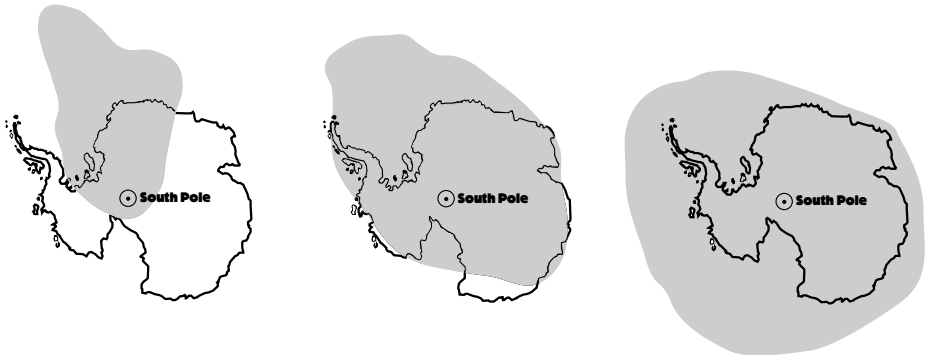


Figure 4-1-2 Ozone hole
Ozone depletion growth over Antarctica from 1980 to 2000. (Ozone hole is represented by the shaded area.)

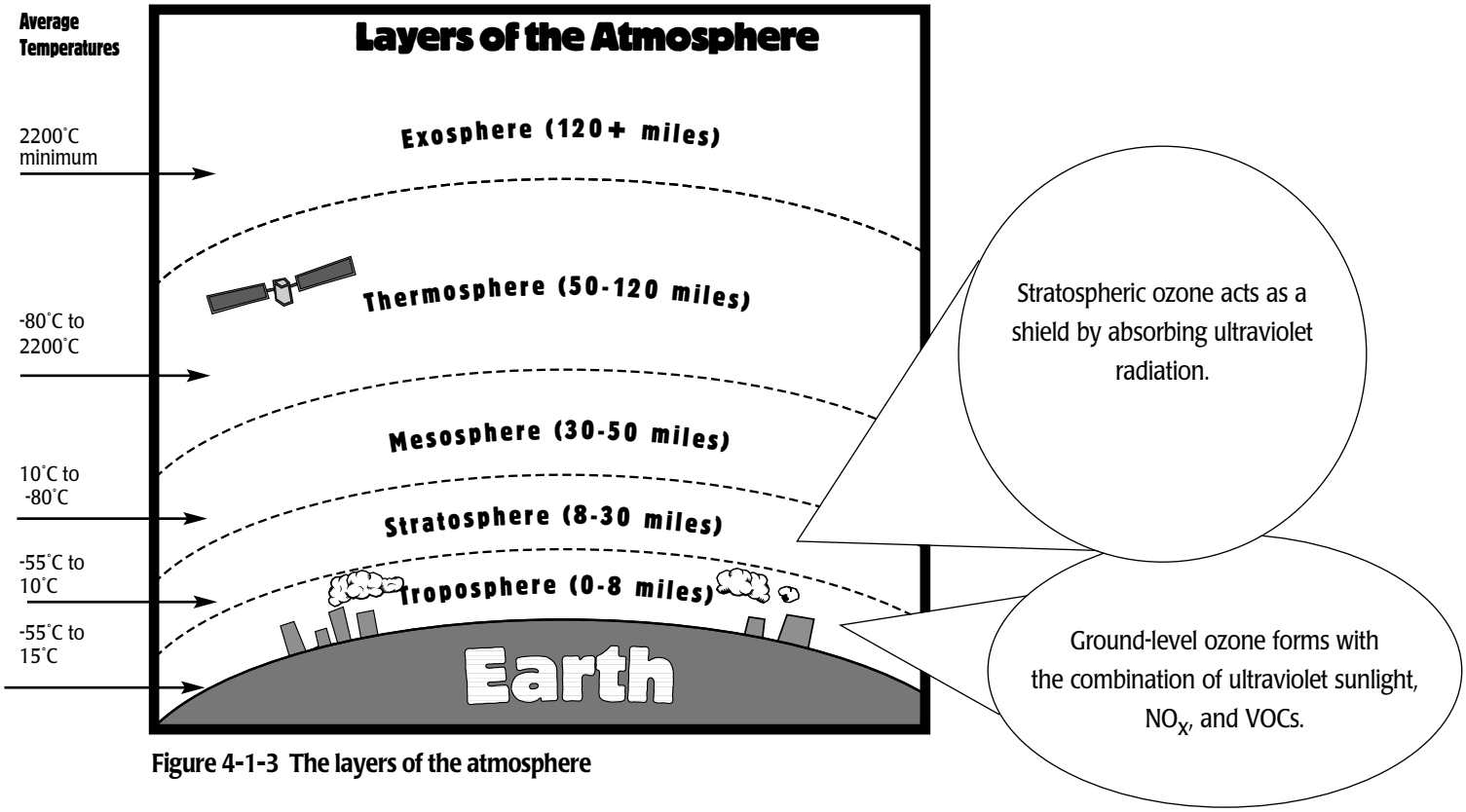


Figure 4-1-3 The layers of the atmosphere

ultraviolet radiation from the sun. This layer is sometimes called the ozonosphere. Life on earth would not exist without the presence of this "shield." Destruction of part of the ozonosphere by certain human-made chemicals allows more ultraviolet radiation to reach the earth's surface.

A "hole" in the stratospheric ozone layer was first discovered over Antarctica by the British Antarctic Survey. Severe thinning of the layer is now observed every winter. The layer replenishes itself—fills in the hole—in the summer. But the size of the hole has been steadily increasing each year.

Large-scale ozone layer destruction would allow enough ultraviolet radiation to reach the earth to cause widespread damage to plants and plankton. These organisms form the base of the food chain, and their destruction would cause problems for all other creatures as well.

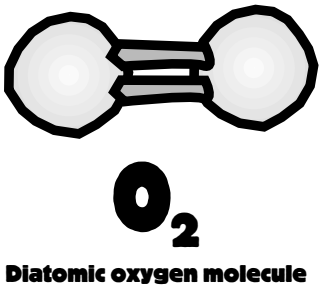
Ozone formation

At ground level, earth's atmosphere consists of many kinds of molecules. A molecule is a combination of atoms bound together. About 78 percent of the molecules in the atmosphere are **nitrogen** molecules, made up of two nitrogen atoms. Twenty-one percent are oxygen molecules, consisting of two oxygen atoms. Most of the rest of the atmosphere at ground level consists of argon, helium, and carbon dioxide. Many other gases, such as ozone, are present in very small amounts.

The formula for diatomic oxygen is usually written as O_2. This form of oxygen is vital to animal life. Ozone (O_3) is a molecule with three oxygen atoms bound together. Pure ozone is an extremely corrosive bluish gas with a pungent smell. It can be useful under controlled conditions. For instance, it is created in factories for use as a bleach, to deodorize air, to purify water, and to treat industrial waste.

Ozone is created when a single oxygen atom reacts with an oxygen molecule. Many chemical reactions in the atmosphere can produce a single, or free, oxygen atom. One reaction that people are able to detect occurs when lightning strikes water droplets. The electric jolt can sever the bonds between water's two atoms of hydrogen and one atom of oxygen, freeing the oxygen atom and allowing it to bond with a regular O_2 molecule to form ozone. If you have ever noticed a peculiar odor in the air after lightning has struck nearby, that is probably ozone.

Most ground-level ozone that causes health concerns is formed when sunlight reacts with air pollution caused by human activities. The pollution that leads to ozone formation can be divided into two categories. One category is molecules called **nitrogen oxides** (NO_x). This refers to both nitrogen oxide molecules (NO) and nitrogen dioxide molecules (NO_2). The other category is a class of hydrocarbons called **volatile organic compounds** (VOCs). Without the combination of lots of ultraviolet sunlight, NO_x, and VOCs, ground-level ozone does not form.



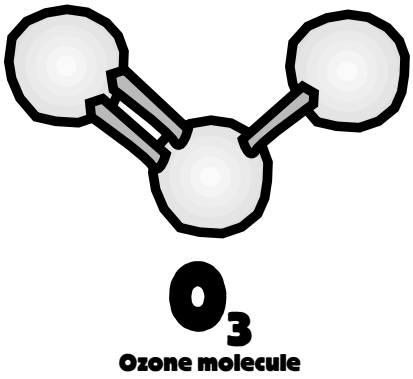


Figure 4-1-4 *Many gaseous elements exist not as individual atoms but as diatomic molecules–molecules consisting of two atoms covalently bonded. O_2 is an example of a **diatomic** molecule. In unstable conditions, diatomic oxygen can bond with a free oxygen atom, resulting in ozone (O_3).*

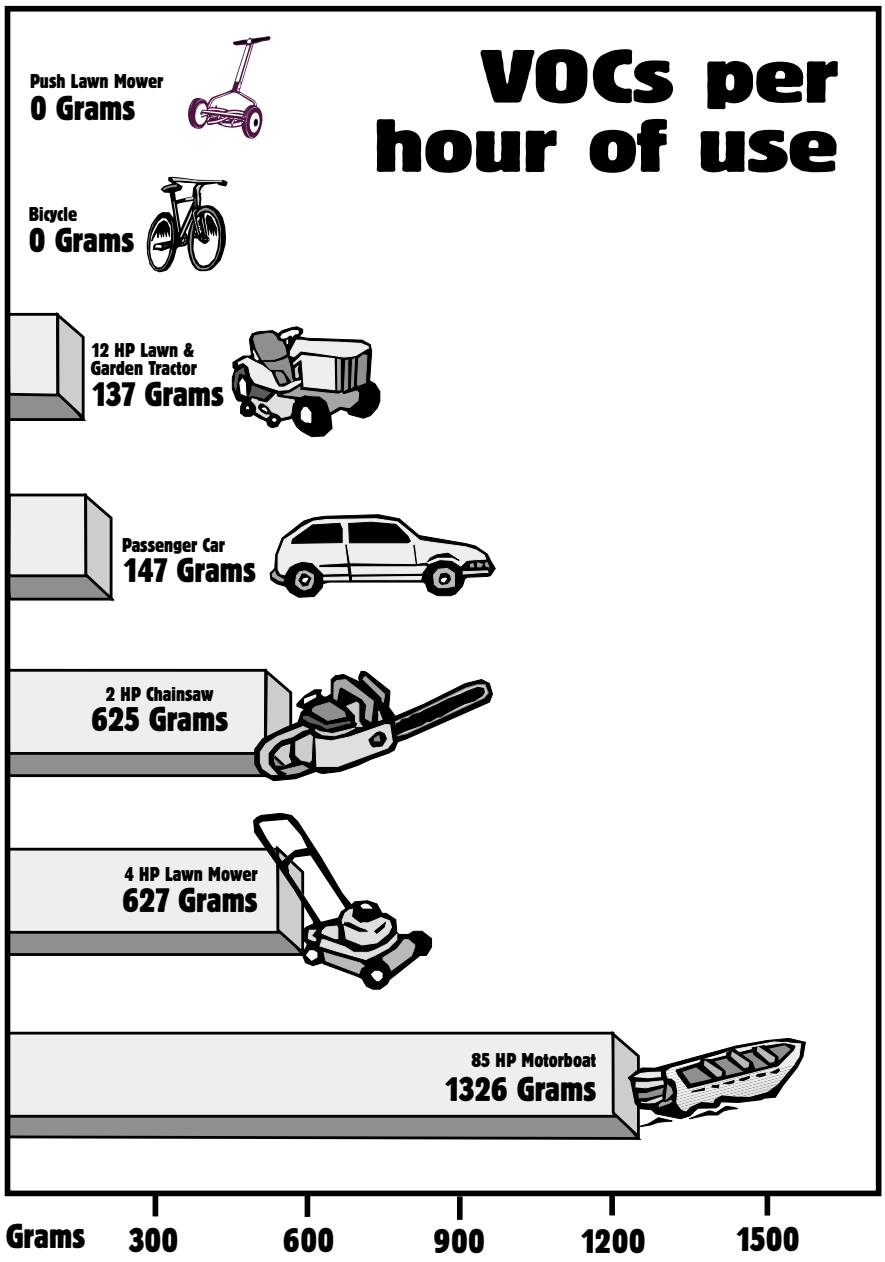


Figure 4-1-5
Ozone-causing VOC emissions per hour of use
Source: U.S. EPA

About half of all of the NO_x and VOCs in the United States, as well as in Texas, enters the atmosphere from the combustion of fuels in vehicles. The exact percentage of the VOC and NO_x emissions that comes from vehicles varies by city. For example, in cities with lots of petrochemical plants, such as the Beaumont/Port Arthur area, around 6 percent of the VOCs and 37 percent of the NO_x comes from vehicles. On the other hand, in areas such as Dallas/Fort Worth, around 50 percent of the VOCs and 87 percent of the NO_x or **reactive emissions** comes from vehicles.

Ozone concentrations

There doesn't have to be much ozone to cause problems. The federal government has enacted a law stating that concentrations of 0.12 parts of ozone per million parts of other air molecules is unhealthy, especially to people with respiratory conditions. The presence of ozone at these levels for long periods of time can cause serious lung irritation. Because of this, cities with ozone problems often have programs that alert people if high ozone levels are expected.

The U.S. Environmental Protection Agency (EPA) has developed the Air Quality Index for reporting the levels of ozone and other common air pollutants. To make it easier for the public to quickly understand the air quality in their communities, EPA has assigned a specific color to each category. For example, the color orange means that conditions are "unhealthy for sensitive groups," the color red means that conditions are "unhealthy" for everyone, and so on (Transparency #30).

Factors in ozone formation

What kind of conditions would result in a "high ozone day"? Fluctuations in an area's ozone level can be attributed partially to variations in weather. Since ozone is formed when NO_x, VOCs, and strong sunlight are present, sunny days with temperatures above 90 degrees may indicate potential high levels of ozone formation. That explains why smog and ozone levels peak during the summer.

Air pollution sources

Natural sources

lightning
pine trees
brush and forest fires
cattle
volcanoes
geysers
wetlands/swamps

Human sources

vehicles
furnaces
open burning
leaf burning
dusty coal piles
power plants
adhesives
petroleum storage
factories
landfills
commercial printers
dry cleaning solvents
filling stations
charcoal grills
lawn mowers
off-road vehicles
jet skis, boats
airplanes
refrigerants
paint, solvents
fireplaces, woodstoves

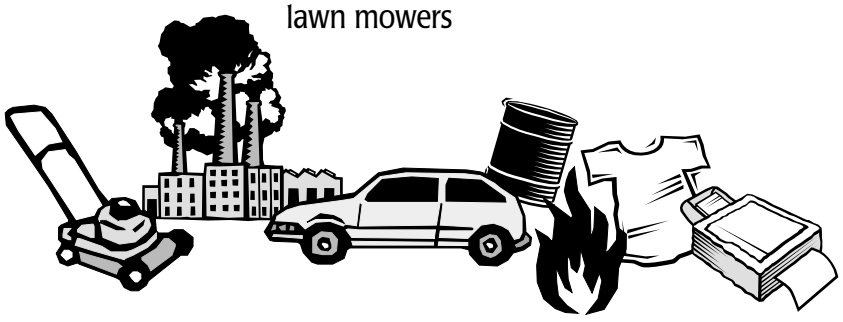
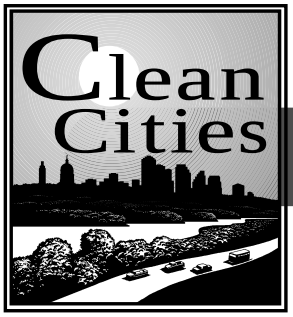


Figure 4-1-6 Air pollution sources

High wind speed and atmospheric circulation usually prevent ozone from settling. Stagnant or low wind speed keeps ozone from dissipating, creating the potential for high levels of smog and ozone. Ozone usually collects when wind speed is under eight miles per hour.

Rain also affects ozone formation. Rain often improves air quality by both "raining out" pollutants and cooling air temperatures. Similarly, cloudy days lower ozone levels by reducing temperatures and sunlight. Ozone alerts usually occur when forecasts call for clear skies or scattered cloud coverage.

Geographical conditions or **topography** also affects ozone formation. Mountains, valleys, and bodies of water affect ozone's ability to dissipate or settle. For example, mountains often block air movement, so that stagnant air collects in the valley between two mountains. In coastal areas, land and sea breezes may transport pollutants offshore during the afternoon (when the land is warmer than the sea) and onshore during the evening (when the sea is warmer than the land).



Clean Cities Coalitions

Clean Cities is a U.S. Department of Energy program designed to encourage the use of alternative fuel vehicles and their underlying support systems nationwide. Clean Cities organizations are built on the premise that we can change our communities for the better through cooperation and voluntary partnerships, working to reduce our reliance on imported oil and improve air quality.

Clean Cities Coalitions were developed to help non-attainment cities meet air quality standards. A non-attainment city is one that exceeds minimum federal air-quality standards. If non-attainment cities do not meet air quality standards within a specified time period, they are subject to enforcement actions such as warnings, court orders, lawsuits, fines, and a reduction of funding for road construction and/or repairs.

Clean Cities Coalitions in Texas include:

Alamo Area Clean Cities Coalition
www.aacog.dst.tx.us/naturalres.htm
Austin Clean Cities Coalition
www.ci.austin.tx.us/cleancities
Dallas-Ft. Worth Clean Cities Coalition
www.nctcog.dst.tx.us/trans/clean_cities
Houston-Galveston Clean Cities Coalition
www.houston-cleancities.org
Paso del Norte Clean Cities Coalition
www.ccities.doe.gov/profiles/pasodeln.html
Texas Coastal Bend Clean Cities Coalition
www.ccities.doe.gov/profiles/corpus.html

Controlling ozone

People can't control the weather or topography, but they can control the emissions from transportation and industry. One way to decrease ozone formation is to decrease emissions of NO_x and VOCs from vehicles. That is one of the chief benefits of alternative fuels. Burning **simple hydrocarbons** such as propane and methane or using other alternative power sources, and properly operating vehicles, cuts reactive **exhaust emissions** dramatically. Emissions-trapping refueling systems and low-volatility fuels also cut down on **evaporative emissions.**

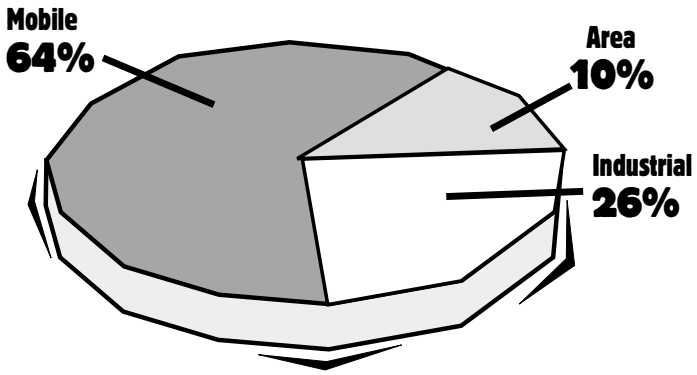


Figure 4-1-7 U.S. sources of nitrogen oxide (NO_x) emissions in non-attainment areas.
Source: U.S. EPA 1997

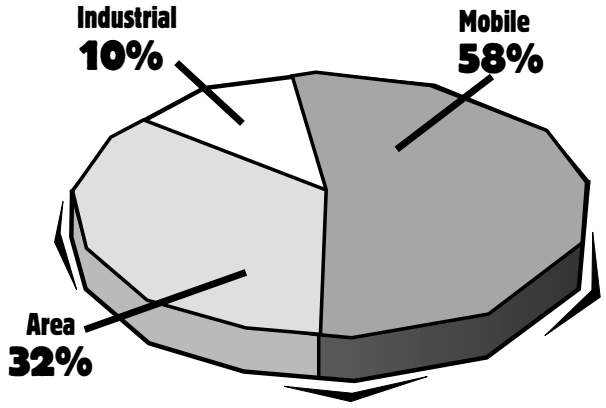


Figure 4-1-8 U.S. sources of volatile organic compound (VOC) emissions in non-attainment areas.
Source: U. S. EPA 1997

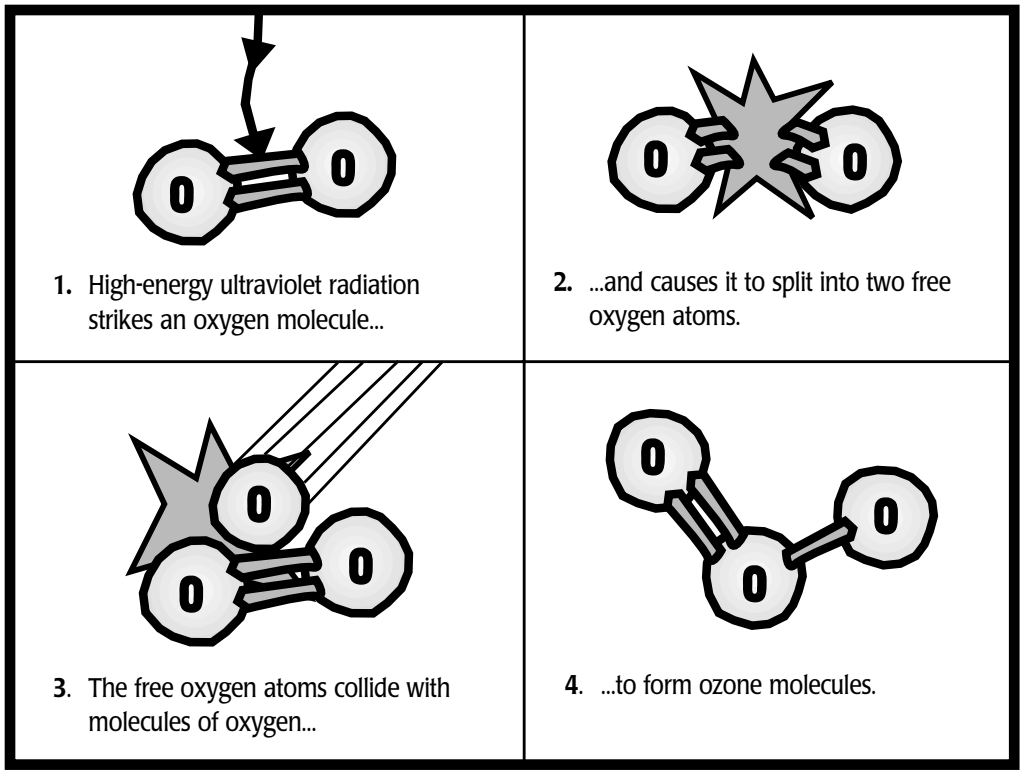


Figure 4-1-9 An example of one of the many different ways ozone forms

On ozone action days, clean-air organizations often suggest ways people can limit ozone-forming emissions. These include:

- *refraining from using* **volatile** *materials such as lighter fluid, varnishes, degreasers, and oil-based paints*
- *limiting use of automobiles, especially in the morning*
- *combining trips to minimize cold starts, when an engine emits more pollutants*
- *putting off use of yard equipment such as gasoline lawn mowers and chain saws*
- *putting off refueling, or at least waiting until evening*

Figure 4-1-10 Ozone action day helpful hints

Ozone Alert Resource List

www.tnrcc.state.tx.us/air/monops/ozoneinfo2.html
Texas Natural Resource Conservation Commission
What ozone is; health hazards; what we can do about ozone; Ozone Action Days Program; ozone attainment status of Texas metropolitan areas (one-hour standards).

www.epa.gov/airs/criteria.html
U.S. Environmental Protection Agency
Explains National Ambient Air Quality Standards established under the federal Clean Air Act for pollutants considered harmful to public health and the environment.

www.veggie-mon.org
University of Texas M.D. Anderson Cancer Center, Science Park-Research Division
The University of Texas at Austin
Environmental health web site for grades 4-8; an animated artichoke ("Veggie Mon") and his friend Strawberry Girl inform younger children about harmful UV exposure. Includes TEKS, experiments, games, and puzzles.

www.epa.gov/kids/odap.htm
Ozone Depletion Art Project, U.S. Environmental Protection Agency
"The Science of Ozone Depletion" has questions and answers about upper-level atmospheric ozone depletion; links to more detailed information.